Interplay Between Lattice QCD and the 12 GeV CEBAF upgrade at Jefferson Lab

We have at hand a unique opportunity for an exciting synergy between theory and experiment that will resolve fundamental questions concerning hadron structure. The proposed Lattice QCD Computing initiative sets the stage for key experiments designed to utilize the 12 GeV CEBAF upgrade at Jefferson Lab and is crucial for the interpretation of the anticipated experimental results; in turn, these experiments will stimulate and provide validation for lattice QCD studies. Both the experimental and theoretical studies are necessary in order to obtain a comprehensive understanding of this scientific thrust. Recent advances in lattice QCD include not only developments in lattice theory but also the advent of multi-teraflop computing, giving confidence that QCD can be solved on the lattice. On the experimental side, the superb characteristics of the electron beam (flux, emittance and duty-factor) at CEBAF, enhanced by an increase in energy to 12 GeV, will open the door for searching for new forms of matter predicted by QCD and greatly extend the ability to probe, in detail, the structure of the nucleon.

- **Location and Timing**: The Lattice QCD Computing Initiative proposes major hardware at three locations, one of them being JLab. This will enhance the already close ties between the theorists and experimentalists. The lattice computer will be operating at the 10 Teraflop level by 2005-2006, close to the proposed construction start of the upgrade. First lattice results will guide the initial experimental searches and studies. The proposed start of operations of the upgraded CEBAF is in 2010, allowing time for the completion of large scale computations necessary for the interpretation of the experimental results.

- **Exotic Hybrid Mesons:** Hybrid Mesons with exotic quantum numbers, for which there is only some tantalizing evidence at present, would be of great importance to QCD. Lattice QCD can unambiguously predict the spectrum of long-lived exotic states. Their unusual quantum numbers are a clean signature of new physics and they arise from the excitation of the gluonic field binding the quarks in a meson. The proposed GlueX experiment, to be housed in Hall D, will be uniquely suited to definitively map out this spectrum using linearly polarized photons. Lattice QCD will be able to calculate masses and decay modes of these mesons from first principles. The ultimate goal of this study is a quantitative understanding of confinement of quarks and gluons in QCD.

- **Quark and Gluon Structure of the Nucleon:** Increasing the energy of CEBAF also allows a measurement of the distribution of the fundamental quark and gluon constituents of the nucleon in a new kinematic regime. The new tool of generalized parton distributions will uncover the fundamental origin of the spin of the nucleon. Enhanced computational power will allow a calculation of this quark and gluon structure from first principles.

Taken together, these new results from experiment and lattice QCD will lead to a new and deeper understanding of how hadrons emerge from QCD.